AMENDMENTS TO THE SPECIFICATION:

Please amend the paragraph beginning on page 1, line 3 and ending on page 1, line 6:

~~This is a division of copending application Serial No. 08/429,469, filed on April 27, 1995 as a continuation of then copending application 07/995,204, filed on December 22, 1992 and now abandoned.~~ This is a division of co-pending application Serial No. 09/639,360 filed August 14, 2000, which is a division of application Serial No. 08/987,267, filed December 9, 1997, now U.S. Patent No. 6,185,326, which is a division of application Serial No. 08/429,469, filed on April 27, 1995, now U.S. Patent No. 5,956,420, which is a continuation of Serial No. 07/995,204, filed December 22, 1992, abandoned.

Please amend the paragraph beginning on page 2, line 19 and ending on page 2, line 24:

There is no problem if the copying is performed from the digital source in a floppy disk or the like. However, a hard copy (analog image) is reproduced again in many cases as to the compatibility or the convenience. Therefore, it is desired to improve the quality of a hard copy.

Please amend the paragraph beginning on page 2, line 25 and ending on page 2, line 29:

In USP No. 4,847,641, a contour line of an image is improved by estimating the original pattern or by using smoothing. However, this method cannot restore the deformed contours which occurred on reading and on printing.

Please amend the paragraph beginning on page 5, line 2 and ending on page 7, line 23:

These and other objects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, and in which:

FIG. 1 is a drawing of an example when the density of characteristic points is thicker than that of the pattern;

FIGS. 2(a), 2(b), 2(c) and 2(d) are diagrams for explaining schematically the processing on the image shown in FIG. 1;

FIGS. 3(a), 3(b), 3(c) and 3(d) are diagrams of examples of characteristic points;

FIG. 4 is a graph of the decision of a multi-level document image;

FIG. 5 is a graph of the decision of a bi-level document image;

FIG. 6 is a block diagram of an image processor of a first embodiment;

FIG. 7 is a block diagram of the image analyzer;

FIG. 8 is a flowchart of the image analysis processor;

FIGS. 9(a) and 9(b) are diagrams of an example of blocking;

FIGS. 10(a) and 10(b) are diagrams of block synthesis for characteristic points;

FIG. 11 is a flowchart of the blocking processing;

FIG. 12 is a flowchart of the characteristic point search processing;

FIG. 13 is a flowchart of the vectorization of peripheral data;

FIG. 14 is a part of a flowchart of the vectorization of irregular points;

FIG. 15 is the other part of the flowchart of the vectorization of irregular points;

FIGS. 16(a) and 16(b) are diagrams of an example of the vectorization of irregular points;

FIG. 17 is a flowchart of the output processing;

FIGS. 18(a) - 18(d) are diagrams for explaining rules for expressing a contour;

FIG. 19 is a block diagram of an image restoration section;

FIG. 20 is a flowchart of image restoration;

FIG. 21 is a flowchart of the restoration of one block;

FIG. 22 is a block diagram of a characteristic point adder;

FIG. 23 is a block diagram of an image processor of a digital copying machine;

FIGS. 24(a), 24(b), 24(c) and 24(d) are diagrams for illustrating the generation of characteristic points;

FIG. 25 is a block diagram of characteristic point generator;

FIG. 26 is a flowchart of the processing of the characteristic point generation processor;

FIG. 27 is a flowchart of characteristic point generation;

FIG. 28 is a flowchart of arc decision;

FIG. 29 is a flowchart of irregular processing;

~~FIG. 30 is a diagram~~ FIGS. 30(a) and 30(b) are diagrams of an example of a layout of a density standard pattern provided on a document;

FIG. 31 is ~~a flowchart of~~ diagram of a flow for reading the density standard pattern;

FIGS. 32(a) and 32(b) are diagrams of density of characteristic points when a plurality of density bands is used;

FIGS. 33(a) and 33(b) are drawings of an image wherein the density changes gradually and of an image wherein the density is constant for each region, respectively;

FIGS. 34(a) and 34(b) are graphs of density change of the images shown in FIGS. 33(a) and 33(b);

FIG. 35(a) is a graph of an example of the density change and FIG. 35(b) is an enlarged view of a part of FIG. 35(a);

FIG. 36 is a diagram of a flow of the processing of distinguishing an image relevant to characteristic points;

FIG. 37 is a block diagram of the addition of characteristic points when an original document is prepared;

FIG. 38 is a block diagram of an image processor and a code processor;

FIG. 39 is a block diagram of a character pattern generator for adding characteristic points to characters;

FIG. 40 is a diagram for illustrating control points expressing a contour of outline font;

FIG. 41 is a diagram for illustrating the generation of characteristic points from control points;

FIGS. 42(a), 42(b), 42(c) and 42(d) are diagrams for detection an error; and

FIG. 43 is a block diagram of an image processor including a read error detection section and an error correction section.

Please amend the paragraph beginning on page 9, line 10 and ending on page 9, line 17:

Both analog information (image data) and digital information (additive information) are read from a hard copy, and the image is restored by extracting the digital ~~information~~ information, and the original image can be restored in a hard copy reproduced by using the additive information. Read errors of the analog information are corrected with use of the digital information. In the restoration, analog image data is not needed.

Please amend the paragraph beginning on page 15, line 11 and ending on page 15, line 23:

In the blocking, first, the image data stored in the image memory 111 is scanned in ~~unit of line~~line units, and if the density is found to change by an amount more than a predetermined amount in a predetermined narrow section during the scan, it is regarded as an edge of a block. Both the starting point and the last point of a line are regarded as edges. In an example shown in FIGS. 9(a) and 9(b), the result of blocking is shown in FIG. 9(a), wherein the two boundaries of a block are represented by marks "<" and ">". Further, "a", "b" and the like represent the names of a restoration distinction number given in series from the start of a line. The restoration distinction number will be explained later.

Please amend the paragraph beginning on page 16, line 27 and ending on page17, line 6:

In the example shown in FIG. 9(a), the blocks in the first line are regarded as new and restoration distinction number of "a", "b", "c", and the like are given to the block successively. The blocks in the second line are regarded as the same block as "a", "b", "c", and the like in the first line. The third line is also processed similarly. A block of restoration distinction number "d" appears in the fourth line. As shown in FIG. 9(b), the block is regarded as the same as a block of restoration distinction number "a", and the block of "c" in the first to third lines are regarded as blocks of "a".

Please amend the paragraph beginning on page 17, line 7 and ending on page17, line 10:

After the blocking ~~completes on~~ is completed for all the lines, characteristic points are removed from the image data. (Practically, the starting point or last point of an adjacent block is changed to synthesize a region).

Please amend the paragraph beginning on page 17, line 11 and ending on page17, line 22:

If the density of a point in a block of flat attribute is ~~decided~~ determined to be within a predetermined range assigned for characteristic points, it is regarded as a characteristic point. The characteristic point is regarded to belong to a block having the longest contact length among adjacent blocks in contact with the characteristic point. If there are blocks of the same longest contact length, it is regarded as belonging to a block having an average density closest to the density of the characteristic point. The characteristic point flag of the block which incorporates the block of characteristic point is set as "1".

Please amend the paragraph beginning on page 18, line 29 and ending on page18, line 33:

If the blocking is completed on all the sections in the line (YES at S129), it is checked next if the blocking is completed on all the lines ~~(S129)~~. If not completed, the flow returns to S121 and the next line is processed. Otherwise the flow returns to the main flow (S13[[0]]1).

Please amend the paragraph beginning on page 21, line 26 and ending on page 22, line 20:

FIGS. 14 and 15 show a flow of the vectorization of irregular points (S106 at FIG. 8). First, the restoration recognition number (ID) of a block to be processed is determined (S161). Next, a characteristic point already vectorized is searched (S162), and characteristic points connected to the characteristic point are searched (S163). Then, it is decided if there are characteristic points within a predetermined short distance (YES at S164), irregular point flags are set for them because they have to be processed in the irregular point processing (S165). Next, if it is decided that one round of the contour has not yet been processed (S166), the flow returns to S163 for next characteristic point in the contour. Otherwise it is decided next if the processing on all the contours is completed or not (S167). If the decision is NO, a block consists of a plurality of contours and the flow returns to S162 for the next contour. If the processing on all the contours is completed, it is decided next if the processing on all the restoration distinction number is completed or not (S168). If it is decided that all the restoration distinction numbers (block IDs) [[is]] are not processed (NO at S168), the flow returns to S161 for the processing of blocks of the next restoration distinction number. If it is decided that all the restoration distinction ~~number is~~ numbers are processed (YES at S168), the flow proceeds to S169 for the connection of contour at irregular points, as shown in examples in FIGS. 16(a) and 16(b).

Please amend the paragraph beginning on page 22, line 21 and ending on page 23, line14:

In the connection processing [[at]] <u>of</u> irregular points, first, the restoration distinction number (block ID) of a block to be processed is determined (S169). Next, a characteristic point (point "a" in FIG. 16(a)) which has not yet been connected is searched (S170). Further, it is decided if there are two other characteristic points not yet connected in the vicinity (S170). If the decision is NO, then the characteristic point is discarded as [[a]] noise (S179) and the flow returns to S170. If there are decided to be two other characteristic points ("b" and "c" in FIG. 16(a)), these points are irregular points. Then, a characteristic point already connected is searched in a predetermined search direction within a predetermined distance (S172). If there are decided to be two connected points ("f" and "g" in FIG. 16(a)) (YES at S173), the irregular points are connected to the two points as a temporary contour ("h" and "i" in FIG. 16(b)) (S176). (The final restored contour is the dashed line "j" in FIG. 16(b).) Then it is decided if there is a characteristic point not yet connected (S177). If the decision is YES, the flow returns to S170 for the processing of the next irregular point. If there is decided no characteristic point not yet connected (NO at S177), it is decided if the processing on all the restoration distinction number is completed or not (S178). If the decision is NO, the flow returns to S169 for the processing of the next restoration distinction number. Otherwise the vectorization completes and the flow returns to the main flow (S180).

Please amend the paragraph beginning on page 23, line 15 and ending on page 23, line 21:

If it is decided that there is not two connected points (NO at S173), the search is performed by expanding the angle (S174), and it is decided again if there are two connected points (S175). If the decision is YES, the flow proceeds to S176 for the connection. Otherwise the characteristic points are discarded as [[a]] noise (S179) and the flow returns to S170.

Please amend the paragraph beginning on page 23, line 23 and ending on page 24, line 4:

FIG. 17 shows a flow of the output processing (S106 in FIG. 8). First, it is decided on a line if there is a request for non-restored data (S201). If there is no request for non-restored data (NO at S201), it is decided if there is a request for a characteristic point on the line (S202). If there is a request for a characteristic point (YES at S202), the restoration distinction number (block ID) on the corresponding coordinate is searched (S203), and the data on the characteristic point with relation to the restoration distinction number is outputted (S204). Then the flow returns to S201. If there is decided to be no request for a characteristic point at S202, it is decided next if all data is outputted or not (S210). If there remains data not processed (NO at S210), the flow returns to S201 for the next processing.

Please amend the paragraph beginning on page 24, line 27 and ending on page 24, line 31:

(2) An arc of short distance is approximated as a short straight line. If the characteristic points are arranged within a short distance, the number of the points are chosen except three in order to prevent ~~the decision~~ processing as irregular points.

Please amend the paragraph beginning on page 26, line 11 and ending on page 26, line 29:

FIG. 21 shows a flow of one block restoration (S406 in FIG. 20). First, a starting point is determined in a contour by searching for a straight portion (S421). The straight portion is decided as shown in FIG. 18(a). That is, an irregular point can be distinguished by the existence of three characteristic points within a predetermined short distance. A straight line is distinguished by characteristic points of a number except three arranged almost linearly and connected to another set of characteristic points with a long straight line. An arc of short distance is distinguished by expressing it as a short straight line. Further, when a center on three characteristic points A, B and C is defined as a point at which a normal of a

straight line between characteristic points A and B crosses another normal of a straight line between characteristic points B and C, an arc can be distinguished when the distances from the center to the three characteristic points are within a predetermined error (refer to FIG. 18(d)).

Please amend the paragraph beginning on page 27, line 30 and ending on page 28, line 11:

FIG. 22 shows the structure of the characteristic point adder 14 wherein a characteristic coordinate is received and the data of a predetermined density is added to the coordinate. A density correction section is not used in this embodiment 141. The density of an image having the same density as characteristic points is shifted in order to prevent the confusion with the characteristic points. A selector 143 selects not the image information, but the density data of a characteristic point when a characteristic point coordinate "b" is received. Thus, the image data and the characteristic point data are synthesized. If the process mode is set in the operational section 16, the addition of characteristic points is prohibited in the selector 143.

Please amend the paragraph beginning on page 30, line 5 and ending on page 30, line 16:

FIGS. 24(a) - 24(d) illustrate how characteristic points are generated. As to as-received image data in a non-restorable region shown in FIG. 24(a), contours are extracted first as shown in FIG. 24(b). If the pattern of the contour is simple, characteristic points can be obtained readily from the contour. On the other hand, in case of a character or the like, smoothing of the data [[are]] is performed in order to remove noises on reading and the contour is approximated with straight lines as shown in FIG. 24(c). Then, the crosses of straight lines located within the pattern are regarded as the coordinates of characteristic points as shown in FIG. 24(d).

Please amend the paragraph beginning on page 31, line 30 and ending on page 32, line 13:

FIG. 27 shows a flow of characteristic point generation (S605 in FIG. 26). First, a characteristic point in the designated restoration distinction number (block ID) is searched (S621), and a contour is resembled up to a length in correspondence to the smallest arc (S622). That is, the contour is traced by calculating the distance on the basis of the block information. Next, an arc decision is performed to decide if the portion is an arc or not (S623). If it is decided to be an arc (YES at S624), a characteristic point next by one pixel is determined (S625), and the arc decision is performed again (S626). If it is decided to be an arc (YES at S627), the flow returns to S625 for the arc decision of the next characteristic point. Otherwise, the data on the characteristic points of the arcs obtained above are sent to the characteristic point memory 187 (S628).

Please amend the paragraph beginning on page 32, line 25 and ending on page 32, line 28:

If it is decided to be neither an arc nor a straight line (NO at S633), data on the section as a short ~~strength~~ straight line are sent to the characteristic point memory 187 (S638).

Please amend the paragraph beginning on page 33, line 26 and ending on page 34, line 2:

With respect to the characteristic points as explained above, the density level of an image is important, and it is a problem to be solved how to read the density correctly. As a technique to normalize the density, a standard pattern is read, and the input data can be corrected according to the density change of the standard pattern, as is used for automatic exposure of a copying machine.

Please amend the paragraph beginning on page 34, line 3 and ending on page 34, line 9:

Such a standard pattern can be printed beforehand in a document at an appropriate position. FIG. [[30]] 30(a) shows an example of a layout of such a

document. A standard pattern is printed at a lowermost left corner of the document. The standard ~~pattern enlarged at the left side~~ pattern, englarged in FIG. 30(b), includes marks of different densities (left) and the density used for the characteristic points (right).

Please amend the paragraph beginning on page 35, line 16 and ending on page 35, line 31:

In an example shown in FIG. 32(a), four densities of I_n (n = 1, 2, 3 and 4) are used for characteristic points, and the three densities of I_n (n = 2, 3 and 4) are within the density region for the image. The as-received image data except the densities I_n for characteristic points are used as image data without processing. FIG. 32(b) shows a situation around the density I_2 for a characteristic point. When a hard copy is generated, characteristic points are written at the predetermined densities I_n. However, the density on the hard copy may scatter due to the quality of hard-copy and the read precision. Then, the scattering width is set as Wa, and the image within the range is regarded as characteristic points. Further, the reading of image data also scatters. Therefore, the image data in the width Wb at both sides of the scattering width Wa are regarded as the same level D_n.

Please amend the paragraph beginning on page 36, line 1 and ending on page 36, line 6:

When a plurality of density bands are assigned to characteristic points in the density range for image, the decrease in dynamic range is a problem. That is, because the density range which can be expressed on a hard copy is limited, when a part thereof is assigned to characteristic points, the range available for an image decreases.

Please amend the paragraph beginning on page 36, line 7 and ending on page 36, line 21:

Further, characteristic points may become ~~noises of image~~image noise. A multi-level half-tone document includes an image wherein the density changes continuously (FIG. 33(a)). In this case, because the densities assigned for the

characteristic points cannot be used, linear noises may happen around the densities. On the other hand, a half-tone image includes an image consisting of areas each of constant density (FIG. 33(b)). In the latter case, the change on image can be avoided by shifting the density a little for the image density around the densities assigned for the characteristic points. In concrete, the density correction section 14 in characteristic point adder 14 in FIG. 22 shifts the density as mentioned above in order to prevent [[the]] confusion with characteristic points of the same density.

Please amend the paragraph beginning on page 36, line 22 and ending on page 36, line 31:

The two kinds of [[image]] images can be distinguished as explained below. For a characteristic point of density I_1 located at a position P_1, as shown in FIGS. 34(a) and (b), the decision is preferably performed both in the vertical and horizontal directions. When the density is read along a direction, if the data changes continuously around I_1, the data is regarded not as a characteristic point, but as an image data. On the other hand, if the data changes discontinuously around I_1, the data are regarded as a characteristic point.

Please amend the paragraph beginning on page 37, line 18 and ending on page 38, line 6:

As explained above, in principle, predetermined density bands are assigned to characteristic points. As shown in FIG. 34(a), if the image density changes gradually, ~~all band is assigned to image~~ all bands are assigned to the image. When the image density changes gradually, it is not needed to get a contour line in such a region wherein the density changes continuously, and there is no problem. On the other hand, if the density for characteristic points is assigned in the document density region for an image wherein the density changed continuously, noises may arise. In the present invention, in order to suppress noises, the sensitivity region for image data is assigned linearly in the document density region. Further, in such an image as shown in FIG. 34(b) wherein the density changes discontinuously, the sensitivity region is changed partly as shown in detail in FIG. 35(b), in order to

express all the data without the density band Wa assigned for characteristic points. That is, the slope of density bands Wb' adjacent to the density band Wa is changed to assign the document density in the density band Wa outside the density band. The width of the density band for changing the band may be expanded to another density band for characteristic points.